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FLAMMABILITY PERFORMANCE OF FABRICS USED FOR CLOTHING AND SEAT KIT COVERS

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19 ABSTRACT (Continue on reverse if necessary and identify by block number)

An important characteristic of the clothing worn by naval aircrewmen is protection from fire and flame be provided. This protection factor is dependent upon the type of material used and any layering that may occur by wearing more than one piece of equipment at a time. In this report, the flammability of the fabrics used for aviator clothing and ejection seat kit covers in the Naval aviation community are examined according to type of material used. They are then catagorized by the degree of protection that is provided against flammability.

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DISCUSSION

The following summary and chart present the current fabrics in use by the fleet in clothing and seat kits, and describes the flammability characteristics of these fabrics. Information ranking each of these fabrics against each other, according to flammability, could not be found at this time. Therefore, the chart is arranged into three categories which have decreasing flammability performance.

Category I contains groups which are variations of Nomex, the variation usually being in weight (oz./yd2) and type of weave or knit. Nomex requires very high temperatures to initiate burning, will char without melting, self extinguishes itself upon removal from the heat source and is also durable with good abrasion resistant characteristics.

Category II is comprised of the items made from leather. Leather is flame resistant, shrinks when in contact with the heat source and is self extinguishing.

Category III contains the nylon and cotton fabrics currently in use on some of the clothing items. All of these fabrics are flammable and cannot withstand high temperatures. Nylon will melt upon contact with the heat source and self extinguish upon removal. Cotton will burn without melting, producing ash and will continue to burn after the source of flame has been removed.

When evaluating the flammability protection of a fabric to be used for clothing, the protection provided to the body must include consideration of the heat and time factor values before the ignition of the fabric. Burns will result if the skin temperature is held above 150°F for one second (Hilado p. 27). In a study conducted by Alice Stoll and Maria Chianta, both the tolerance time to absorbed thermal energy, and the protection provided to the skin by specific fabrics, were evaluated. From this study, the benefit of multiple layers of protective fabric was shown and a ranking of the tested fire resistant fabrics was established. The listing of fabrics primarily contains variations of Nomex and indicates better protection being provided by the samples of greater weight (oz/yd2). From this table a comparison with the fabrics tested and the fabrics in use can be made to some extent, but more importantly it supports the practice of providing as many pieces of Nomex clothing as possible to allow for layering. The layers increase the thickness of the Nomex which provides greater protection against the potential flaming of the garments and the rate of heat flux to the skin.

In the clothing area, the newer pieces that have been introduced, or are being introduced, to the fleet are all made of at least one layer of Nomex. Some garments made of the more flammable fabrics of nylon and cotton are still being used by the fleet. Using Nomex fabrics for these garments would allow for layering of the fabric providing even greater and better protection from fire to the aircrew member. In cooler temperatures, the members of the fleet usually wear a layer of the thermal, Nomex underwear providing at least one layer of fireproof fabric between themselves and the heat source. But, during warm weather the Flyers Coverall may be the only layer of Nomex worn by some crewmen since both the survival vest and torso harness are still fabricated of nylon.

New fabrics and finishes are being developed in the area of flammability to improve upon fabric performance and protection. The fabrics presently in the system are the best that could be found for the purpose at the time of procurement. Currently, new fabrics with better flame resistance, and new finishes which would provide flame resistance to fabrics which are otherwise flammable, are being investigated for potential use in the system. Nomex provides good protection especially when layered, but it now appears that there may be better products available depending upon the types of weaves, knits, weights and colors required.

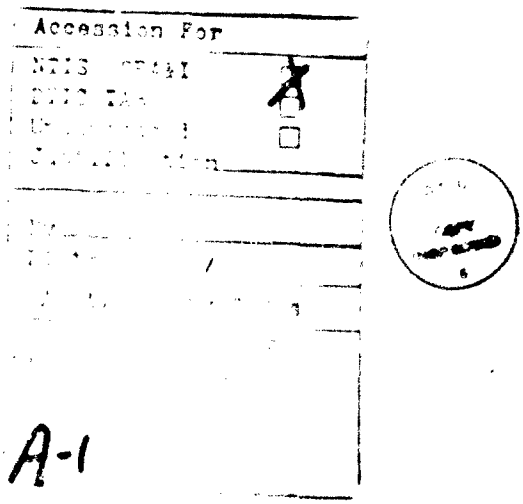
The recommendation at this time is to facilitate replacement of the more flammable clothing with the less flammable counterpart to ensure that all aircrewmen are wearing as many layers of flame resistant clothing as possible. It is also suggested that more meaningful tests be performed on the fabrics that are being developed for use in environments requiring non-flammable fabrics. These tests should be designed to quantify the protection levels, i.e. time to pain, time to blister and burn intensity rather than more conventional tests which measure effects on the fabrics such as flame time, glow time and char length. These tests would allow for comparison of fabrics against each other, demonstrate the level of protection provided and direct researchers in developing new and better fabrics and finishes in this field.

FABRIC CHARTS

Some of the fabrics listed on the proceeding chart have flammability requirements included in the military specification. These are listed on the chart in the flammability column as follows.

- after flame time: time the specimen continues to burn after the flame is shut off.
- after glow time: time the specimen continues to glow after it has ceased to flame.
- char length: distance from the end of the specimen, which was exposed to the flame, to the end of center of charred area.

These numbers insure minimum performance of the fabrics and provide some comparison data.



FABRIC	ITEM	FLAMMABILITY
I Aramid (Nomex)		
A MIL-C 85637, Laminated, Fire Resistant, Waterproof and Moisture Vapor Permeable	62 P Anti Exposure Coverall	After flame time, seconds 2 Char length, inches 5 This fabric is produced through lamination of fabrics B and C with Goretex. These layers provide the flame protection.
B 1) MIL-C 83429A Aramid (Nomex), woven 2) MIL-C 43600, Type II Aramid (Nomex), twill cloth (Fabrics are the same except for type of weave) 3) MIL-C 83283 Aramid (Nomex) oxford cloth	1) a 62 P Anti Exposure Coverall, outer shell b Outside cover, personal life preserver c CWU 27 P (sage green), CWU 27/P (blue) Summer Flyer's Coveralls 2) CWU 33/P Anti Exposure Coverall, outer shell 3) CWU 1/P Intermediate Flyer's Coveralls	Flaming time, seconds 2 Glow time, seconds 25 Char length, inches 3.5 Nomex properties include: – High temperature required for degradation – Fibers char without melting or dripping, do not char at less than 675°F (357°C) – Any burning will be self extinguishing when the high temperature is removed – Remains protective after exposure to high amounts of thermal energy. – Good abrasion characteristics.
C) MIL-C 85636,(AS) Aramid (Nomex), Jersey knit	62/P Anti Exposure Coverall, inner shell backing material	After flame time, seconds 1.0 After glow time, seconds 25.0 Char length, inches 5.0 Nomex flammability properties same as B
D. MIL-C 81814 Aramid (Nomex) (Different weight and flammability requirements than section II)	1) CWU 36/P Summer Flyer's Jacket 2) CWU 18/P Extreme Cold Weather Trousers 3) CWU 17/P, CWU 45/P, Cold Weather Flyer's Jackets 4) Winter Flyer's Hood 5) CSU 15/P Anti G Garment	After flame time, seconds 1 After glow time, seconds 14 Char length, inches 3.5 Nomex flammability properties same as B
E MIL-C 81813A Aramid (Nomex), Quilted Batting	1) CWU 36/P Lining, Summer Flyer's Coverall 2) CWU 18/P Lining Extreme Cold Weather Trousers 3) CWU 17/P & CWU 45/P Cold Weather Flyer's Jackets Lining	Flame time, seconds 2 Glow time, seconds 25 Char length, inches 5.0 No melting will not char at a temperature less than 675°F (357°C)

	FABRIC	ITEM	FLAMMABILITY
F.	MIL-C-85038, Type I Aramid (Nomex) Waffle Type, thermal circular knit	CWU43/P, CWU 44/P, Cold Weather Underwear.	The spec does not contain a flammability requirement, but because his is a Nomex cloth, it can be assumed to meet the same criteria defined in section B.
G. 1)	MIL C 7219E Aramid (Nomex)	1) Seat Cushion Cover for the following Survival kits a. RSSK 1 b. RSSK 8 c. RSSK 9 d. RSSK 3 e. SKU 3/A	See section B.
2)	Nomex "Honeycomb" (no number)	2) Seat Cushion Cover a. SKU 4/A b. SKU 6/A	
H. 1)	MIL-R 5001, Type II Flame resistant, Grade A Latex Foam Rubber	1) Foam Core used in seat cushions of the following survival kits: a. RSSK 1 b. RSSK 8 c. RSSK 6 d. RSSK 9 e. RSSK 3	1) Shall support a flame not longer than 50 seconds after removal from the flame 2) Unstable over 180°F (82.2°C). Urethane foams: flammable.
2)	DYNA modified polyurethane, open cell foam.	2) Foam core used in seat cushions of the following survival kits: a. SKU 4/A b. SKU 6/A	
3)	Safecrest urethane foam		

FABRIC	ITEM	FLAMMABILITY
II. Leather		
1 1) KKL L 254 Non-treated water resistant leather	1)a GS F3P 2 Fire Resistent Flyer's Gloves b. HAU 8 P Lined Gloves c Edge roll on helmet for fixed wing aircraft. Type A or B Class 1, A	Leather is not flame proof but it is flame resistent and does provide protection, shrinks and is self extinguishing, does not melt
2) KKL L 162 Non treated leather	2) Type G 1 Intermediate Flyer's Jacket	
3) Water Resista Leather	3)a Flyer's Boot b Aircrew Safety Boot	
III Nylon and Cotton		
J 1) MIL-C 608, Type I Nylon, oxford cloth	1)a Winter Flyer's Suit b Lining, Type G 1, intermediate Flyer's Jacket c MK 2A Coveralls, Anti G Coverall d SV 28 Survival vest	None of these fabrics has a flammability requirement included in the spec. Nylon cannot withstand extremely high temperatures and will melt. It will self extinguish after removal from source of flame. If not solution dyed the dye may continue to burn off
2) MIL C 19002, Type I Nylon base polychloroprene coating	2)a GD 1/CWU 16/P Quick Donning Anti Exposure Coverall b Anti Exposure Mittens c Anti Exposure Hood d Life Preserver	It should be kept in mind that all of these pieces are worn over other garments that are usually non flammable.
3) MIL-C 43191, Wind resistant sateen, cotton and nylon	3) Cover, small arms protective body armor	
4) Nylon Webbing	4) HBU 11/P Torso Harness	
K 1) Cotton Ventile	1)a CWU 21/P Anti Exposure Coverall b CWU 50/P Anti Exposure Coverall	1) No flammability requirements
2) MIL-C 18387, Cotton	2)a CWU 23/P Liner winterlining b. Winter Flyer's suit over shell	2) Flame time, seconds 2.0 Glow time, seconds 2.0 Char length, inches 5.5 Cotton cannot withstand high temperatures, will burn without melting, continues to burn after has been removed.

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